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June 1994



Physics 30
Grade 12 Diploma Examination

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June 1994

Physics 30

Grade 12 Diploma Examination

Description

Time allotted: 2.5 h. You may take an additional 0.5 h to complete the examination if needed.

Total possible marks: 70

This is a **closed-book** examination consisting of **three** parts:

Part A

has 42 multiple-choice questions each with a value of one mark.

Part B

has 7 numerical-response questions each with a value of one mark.

Part C

has 4 written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference.

Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Carefully read the instructions for each part before proceeding.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Do not fold the answer sheet.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.*

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Part A: Multiple Choice

42 Questions

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully and decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This diploma examination is for the subject of

- A. biology
- B. physics
- C. chemistry
- D. mathematics

Answer Sheet

Ⓐ ● Ⓒ Ⓓ

- Use an **HB pencil only**.
- If you wish to change an answer, erase **all** traces of your first answer.

***Note:** The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.*

Do not turn the page to start the examination until told to do so by the presiding examiner.



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1. The wave theory of light provides the best explanation for which pair of light properties?

- A. Straight-line propagation and refraction
- B. Dispersion and the photoelectric effect
- C. Interference and diffraction
- D. Reflection and dispersion

2. A glass prism separates white light into colours because

- A. the prism adds colour to the white light as it is scattered by the glass molecules
- B. light in the prism travels at different speeds for different colours
- C. the wavelength of light increases as it enters the glass
- D. Snell's Law is not valid for prisms

Use the following information to answer question 3.

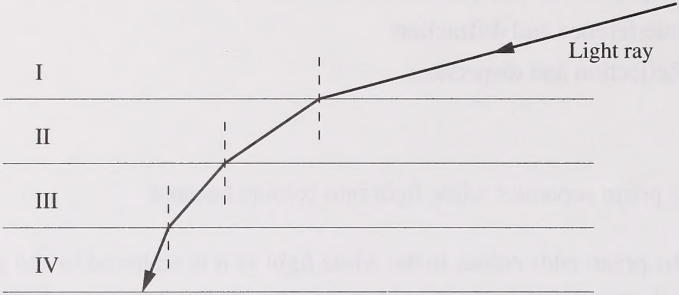
- I The angle of incidence and the angle of reflection are equal.
- II The sines of the angles of incidence and refraction are equal.
- III The incident ray and the reflected ray are perpendicular.
- IV The incident ray, the reflected ray, and the normal all lie in one plane.

3. Which statements describe reflection?

- A. I and II
- B. I and IV
- C. II and III
- D. II and IV

Use the following information to answer question 4.

Light Incident on a Multilayer

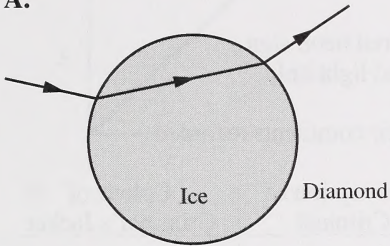


The diagram shows four layers of transparent liquids, one on top of the other. The liquids do not mix. An oblique ray of light travels through the liquids as shown.

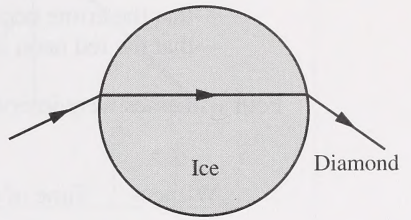
4. In which liquid is the speed of the light ray the slowest?
- A. I
 - B. II
 - C. III
 - D. IV
- _____
5. When light passes through a double slit, the spacing between interference maxima varies
- A. directly as the distance between the slits
 - B. directly as the intensity of the incident light
 - C. inversely as the distance between the slits
 - D. inversely as the wavelength of the incident light

6. Which diagram shows the path of a light ray in diamond ($n = 2.42$) when the light ray encounters a spherical pocket of ice ($n = 1.33$)?

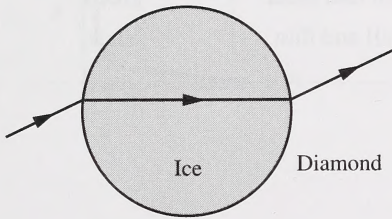
A.



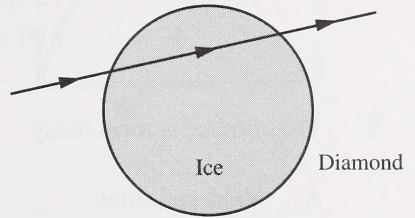
B.



C.



D.



Use the following information to answer question 7.

While investigating a crime that took place in a dark alley, a police officer determined

- that the crime occurred under a red neon sign
- that the red neon sign emitted red light only

Four witnesses were interviewed and their comments recorded.

Witness	Time of Crime	Description of Criminal	Colour of Criminal's Jacket
1	2:00 A.M.	short and stout	yellow
2	2:30 A.M.	short and thin	blue
3	1:30 A.M.	tall and stout	green
4	1:00 A.M.	tall and thin	black

7. The criminal is **most** likely

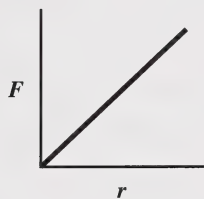
- A. short and stout
 - B. short and thin
 - C. tall and stout
 - D. tall and thin
-

8. The number of electrons represented by a charge of 2.5 C is

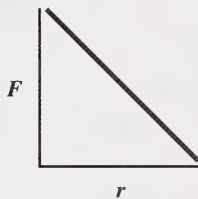
- A. 2.5×10^{18}
- B. 6.4×10^{18}
- C. 1.6×10^{19}
- D. 4.0×10^{19}

9. Two point charges are separated by a distance r . The graph that **best** shows the relationship between the magnitude of the electric force F and the separation r is

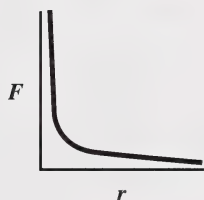
A.



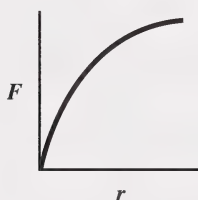
B.



C.



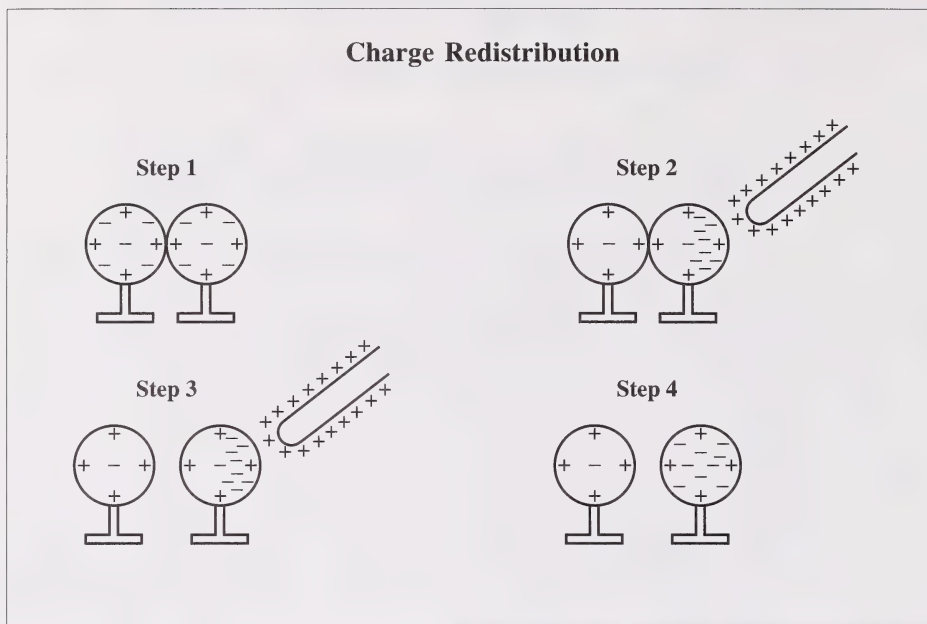
D.



10. The quantity that **cannot** be represented by a vector field is

- A. electric potential
- B. magnetic force
- C. electric force
- D. wind velocity

Use the following information to answer question 11.



11. The overall process indicated by steps 1 to 4 is

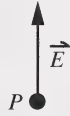
- A. magnetization
- B. polarization
- C. conduction
- D. induction

12. In a Millikan oil drop experiment, the plates are 3.0 cm apart and an oil drop of mass 2.6×10^{-9} g is suspended between the plates. The potential difference between the plates is 260 V. The charge on the oil drop is

- A. 2.9×10^{-15} C
- B. 2.9×10^{-13} C
- C. 2.9×10^{-12} C
- D. 2.9×10^{-10} C

Use the following information to answer question 13.

Changing Electric Field



The diagram represents the magnitude and direction of the electric field at P as a result of the equal positive charges X and Y .

13. If the magnitude of charge X were increased, the electric field at P would be

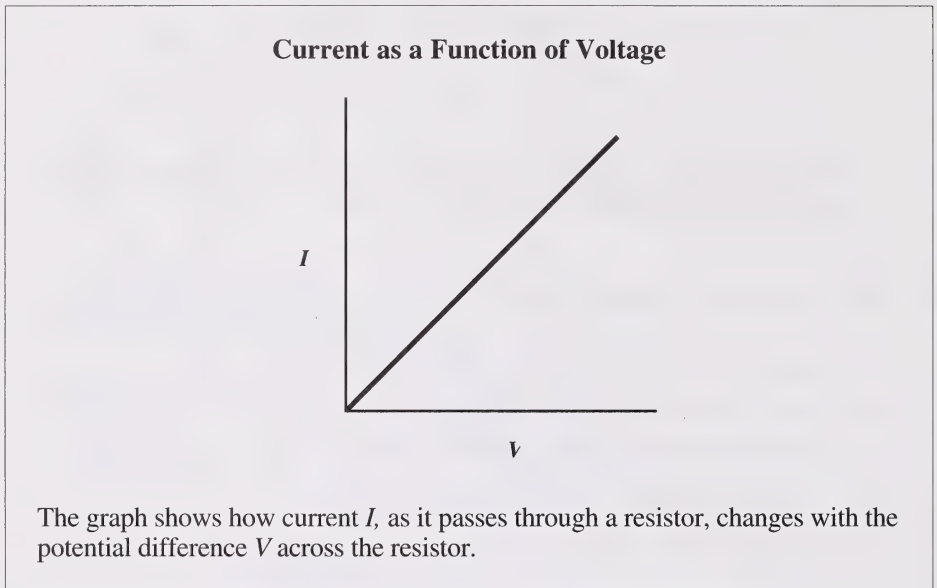
- A. greater and would rotate counterclockwise
 - B. greater and would rotate clockwise
 - C. smaller and would rotate counterclockwise
 - D. smaller and would rotate clockwise
-

14. The equation $I = \frac{V}{R}$ where R is a constant is a form of

- A. Ohm's Law
- B. Volta's Law
- C. Ampère's Law
- D. Coulomb's Law

15. If an electron in a cathode ray tube is accelerated through a potential difference of 5.0×10^3 V, what is its maximum speed?
- A. 8.0×10^{16} m/s
 - B. 1.8×10^{15} m/s
 - C. 3.0×10^8 m/s
 - D. 4.2×10^7 m/s

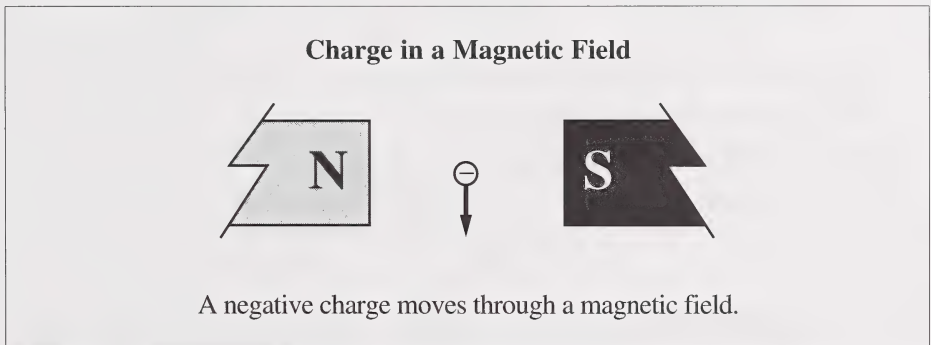
Use the following information to answer question 16.



16. As the potential difference is increased from zero,
- A. the resistance increases and the power remains constant
 - B. the resistance remains constant and the power increases
 - C. the resistance and power both remain constant
 - D. the resistance and power both increase

17. The magnetic force on a charged particle moving through a magnetic field depends on all of the following **except**
- A. mass of the particle
 - B. magnitude of the charge
 - C. strength of magnetic field
 - D. angle at which the particle enters the magnetic field
18. The tesla is equivalent to
- A. $(\text{N}\cdot\text{m}^2)/\text{C}^2$
 - B. $(\text{N}\cdot\text{m})/(\text{C}\cdot\text{s})$
 - C. $(\text{N}\cdot\text{C})/(\text{m}\cdot\text{s})$
 - D. $(\text{N}\cdot\text{s})/(\text{C}\cdot\text{m})$

Use the following information to answer question 19.

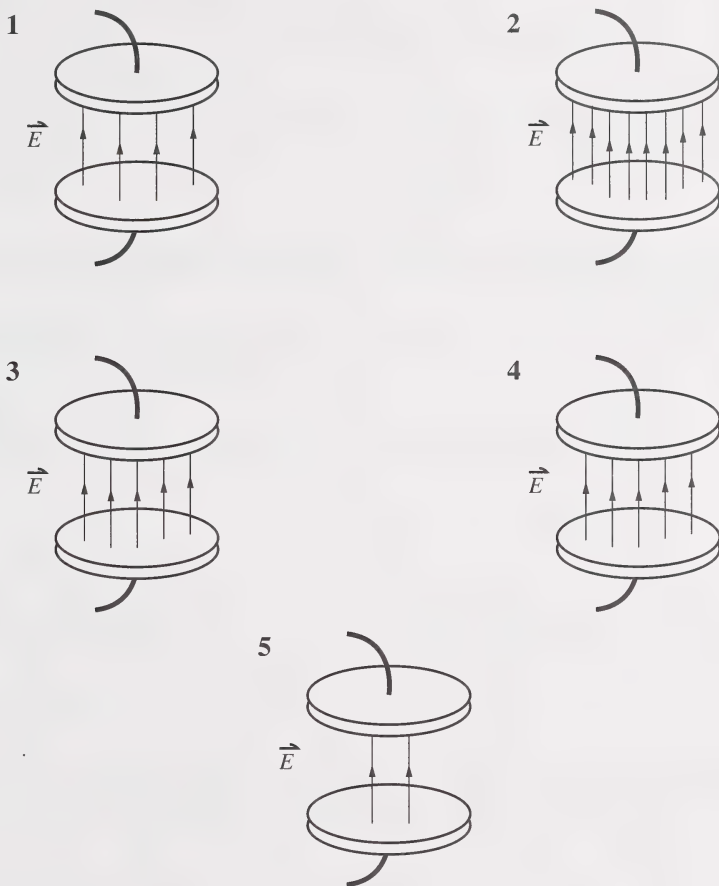


19. The charge will be deflected
- A. toward the left side of the page
 - B. toward the right side of the page
 - C. out of the page
 - D. into the page

20. A 0.50 m length of copper wire is perpendicular to a magnetic field that has a strength of 0.30 T. When a magnetic force of 4.0 N acts on the wire, the current in the wire is equal to
- A. 27 A
 - B. 2.4 A
 - C. 0.60 A
 - D. 0.15 A
21. A magnetic field exerts no force on
- A. a magnet
 - B. an iron bar
 - C. an electric current
 - D. a stationary electric charge
22. Electromagnetic radiation is produced by charged particles that are
- A. travelling parallel to a fixed magnetic field
 - B. moving at the speed of light
 - C. travelling at constant speed
 - D. being accelerated
23. Which quantity is the same for all microwave radiation?
- A. Electric field strength
 - B. Speed in vacuum
 - C. Frequency
 - D. Period

Use the following information to answer question 24.

Parallel Plates



The diagrams represent a pair of electrically charged plates at successive time intervals. The number of lines represents the relative strength of the electric field.

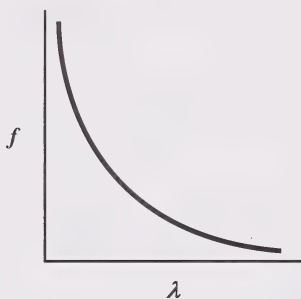
24. A magnetic field must be produced during the interval(s) between
- A. 3–4 only
 - B. 1–2 and 3–4 only
 - C. 2–3 and 4–5 only
 - D. 1–2, 2–3, and 4–5 only

25. A television set receives a signal by direct transmission and receives a reflected signal 1.0×10^{-6} s later. The difference in the path lengths for the two signals is

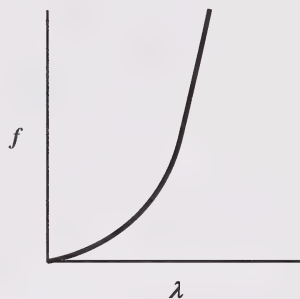
- A. 3.0×10^2 m
- B. 1.0×10^4 m
- C. 3.0×10^5 m
- D. 3.0×10^8 m

26. The relationship between frequency f and wavelength λ of electromagnetic waves is indicated by

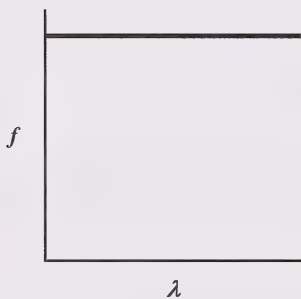
A.



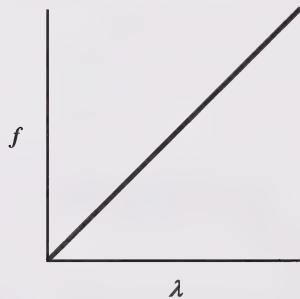
B.



C.



D.



27. The direction of propagation of an electromagnetic wave is
- A. perpendicular to the magnetic field only
 - B. perpendicular to both the electric and the magnetic fields
 - C. parallel to the electric field only
 - D. parallel to both the electric and the magnetic fields

Use the following information to answer question 28.

A spaceship leaves Earth and accelerates to a speed of $3c/4$. A light signal is then sent from Earth to the spaceship.

28. The measured speed of the light signal relative to the spaceship will be
- A. $4c/3$
 - B. c
 - C. $3c/4$
 - D. $c/4$
-
29. In the electrolysis of silver nitrate (AgNO_3 where silver ions are Ag^+), the current necessary to deposit 1.9 g of silver in 0.50 h is
- A. $6.2 \times 10^{-3} \text{ A}$
 - B. $7.8 \times 10^{-2} \text{ A}$
 - C. 0.94 A
 - D. 11 A

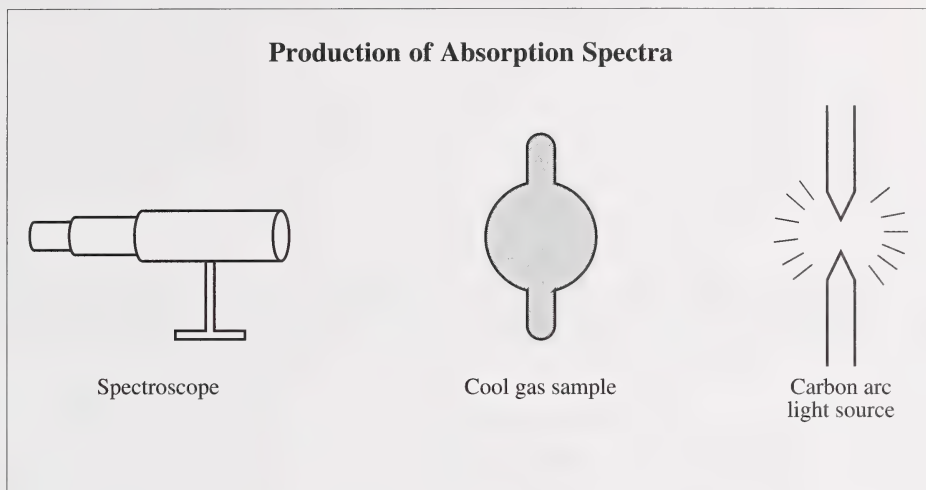
30. The number of silver atoms deposited during electrolysis is directly proportional to the
- A. current
 - B. atomic mass
 - C. electron speed
 - D. valence (ionic charge)

Use the following information to answer questions 31 and 32.

An ionized particle is accelerated from rest to a speed v of 2.50×10^4 m/s. It is then projected perpendicularly through a magnetic field B of intensity 4.00×10^{-2} T, where it follows a curved path of radius R of 4.50×10^{-2} m.

31. The numerical value of $v/(BR)$ in SI base units is
- A. 1.76×10^{11}
 - B. 9.58×10^7
 - C. 1.39×10^7
 - D. 2.81×10^4
32. The SI units of $v/(BR)$ are
- A. N/A
 - B. m/s
 - C. J/C
 - D. C/kg

Use the following information to answer question 33.



33. An absorption spectrum would result from
- A. an electron changing energy levels in the gas sample
 - B. an electron changing energy levels in the light source
 - C. a deficiency in energy of the light source compared to energy in the gas sample
 - D. destructive interference when waves from the light source and the gas sample meet out of phase
-
34. If electrons moving at 3.0×10^6 m/s strike a metal target, the minimum wavelength of the emitted X-ray radiation will be
- A. 2.0×10^{-17} m
 - B. 8.1×10^{-17} m
 - C. 6.1×10^{-10} m
 - D. 4.9×10^{-8} m

35. The transition of an electron from a -3.05 eV energy level to a -8.05 eV energy level results in the emission of a photon of radiation with a wavelength of
- A. 1.12×10^{-7} m
 - B. 1.54×10^{-7} m
 - C. 2.49×10^{-7} m
 - D. 4.07×10^{-7} m
36. If a photoelectric device is illuminated by light with a frequency greater than threshold frequency, what will happen as the frequency of the light is increased?
- A. The photoelectric current will increase.
 - B. More photoelectrons will be emitted.
 - C. The work function of the device will increase.
 - D. Photoelectrons will be emitted with greater energy.
37. When the maximum kinetic energy of photoelectrons is plotted as a function of the frequency of the light causing their emission, the slope of the graph represents
- A. Coulomb's electrostatic constant
 - B. Newton's gravitational constant
 - C. Rydberg's constant
 - D. Planck's constant

38. The momentum of a photon that has an energy of 4.0 eV is
- A. $2.1 \times 10^{-27} \text{ kg}\cdot\text{m/s}$
 - B. $6.4 \times 10^{-19} \text{ kg}\cdot\text{m/s}$
 - C. $1.9 \times 10^{-10} \text{ kg}\cdot\text{m/s}$
 - D. $1.3 \times 10^{-8} \text{ kg}\cdot\text{m/s}$
39. If an electromagnetic wave has a frequency of $1.30 \times 10^{13} \text{ Hz}$, the momentum of its photon is
- A. $3.48 \times 10^{-28} \text{ kg}\cdot\text{m/s}$
 - B. $2.87 \times 10^{-29} \text{ kg}\cdot\text{m/s}$
 - C. $5.10 \times 10^{-47} \text{ kg}\cdot\text{m/s}$
 - D. $1.70 \times 10^{-55} \text{ kg}\cdot\text{m/s}$
40. If each of the following particles were travelling at the same speed, the particle with the greatest de Broglie wavelength would be the
- A. proton
 - B. electron
 - C. alpha particle
 - D. hydrogen atom

41. A photon's momentum will decrease when its

- A. speed increases
- B. energy decreases
- C. frequency increases
- D. wavelength decreases

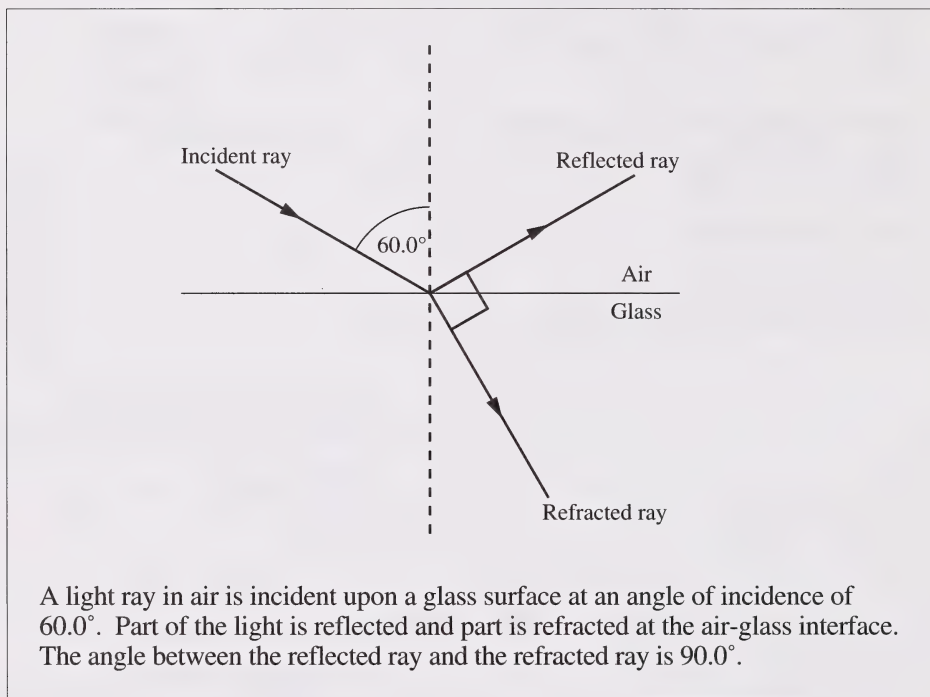
42. The quantum mechanical model of the atom is

- A. physical
- B. empirical
- C. mechanical
- D. mathematical

You have now completed Part A. Proceed directly to Part B.

1. Light passing through a double slit of separation 3.0×10^{-5} m produces a first-order maximum 3.0 cm from the central maximum on a screen 1.5 m away. The frequency of the light, expressed in scientific notation, is $b \times 10^w$ Hz. The numerical value of the exponent w is _____.

Use the following information to answer question 2.



2. The refractive index of the glass is _____.
(Round and record your answer to three digits.)

3. Two parallel plates with a separation of 6.0×10^{-3} m have a potential difference of 120 V across them. The electrical force on an electron placed between the plates, expressed in scientific notation, is $b \times 10^{-w}$ N. The numerical value of the exponent w is _____.

RECORD YOUR ANSWER ON THE ANSWER SHEET

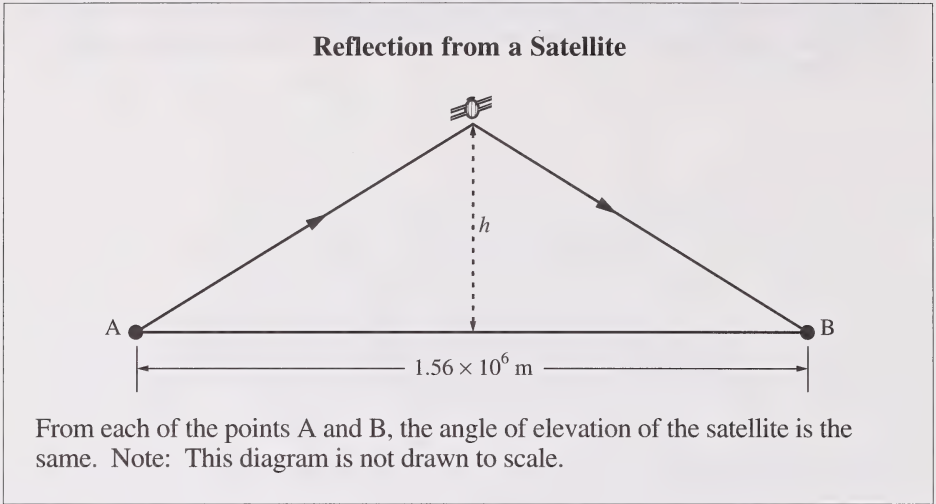
4. The resistance of a 1.51 kW electric heater that operates at 117 V is _____ Ω .
(Round and record your answer to three digits.)

RECORD YOUR ANSWER ON THE ANSWER SHEET

5. The threshold frequency for a metal is 1.40×10^{15} Hz. The work function for the metal, expressed in scientific notation, is $b \times 10^{-w}$ J. The value of b is _____.
(Round and record your answer to three digits.)

RECORD YOUR ANSWER ON THE ANSWER SHEET

Use the following information to answer question 6.



6. Neglecting the curvature of the Earth, if the time taken for a signal to travel from A to B via the satellite is $5.31 \times 10^{-3} \text{ s}$, then the height of the satellite above the surface of the Earth is $b \times 10^5 \text{ m}$. The value of b is _____.
(Round and record your answer to three digits.)

7. An electron has a speed of $1.09 \times 10^6 \text{ m/s}$. The de Broglie wavelength, expressed in scientific notation, is $b \times 10^{-w} \text{ m}$. The value of b is _____.
(Round and record your answer to three digits.)

You have now completed Part B. Proceed directly to Part C.

Part C: Written Response

4 Questions

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers **must show all** pertinent explanations, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences for a written response, and correct units and significant digits for a numerical response.

Note: The perforated pages at the back of this booklet may be torn out and used for your rough work. ***No marks*** will be given for work done on the tear-out pages.

Start Part C immediately.

(5 marks)

1. Monochromatic light with a frequency of 2.35×10^{15} Hz shines on a photoelectric cell. The stopping voltage is 8.76 V. The escaping photoelectrons enter perpendicularly into a magnetic field of strength 2.83×10^{-4} T. Calculate the radius of curvature of the path of the fastest photoelectrons.

Note: If you are unable to determine the maximum energy of the photoelectrons, use the hypothetical value $E_k = 2.4 \times 10^{-18}$ J. Solutions using this value will receive a maximum of four marks.

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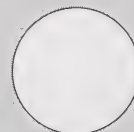


(4 marks)

2. A 404 kg satellite circles the Earth at an average distance of 8.00×10^5 m. The radius of the Earth is 6.37×10^6 m. The orbital period for the satellite is 101 minutes. Determine the mass of the Earth from this information.

Note: If you are unable to find the centripetal force, use the hypothetical value of $F_c = 3.33 \times 10^3$ N. Solutions using this value will receive a maximum of 2 marks.

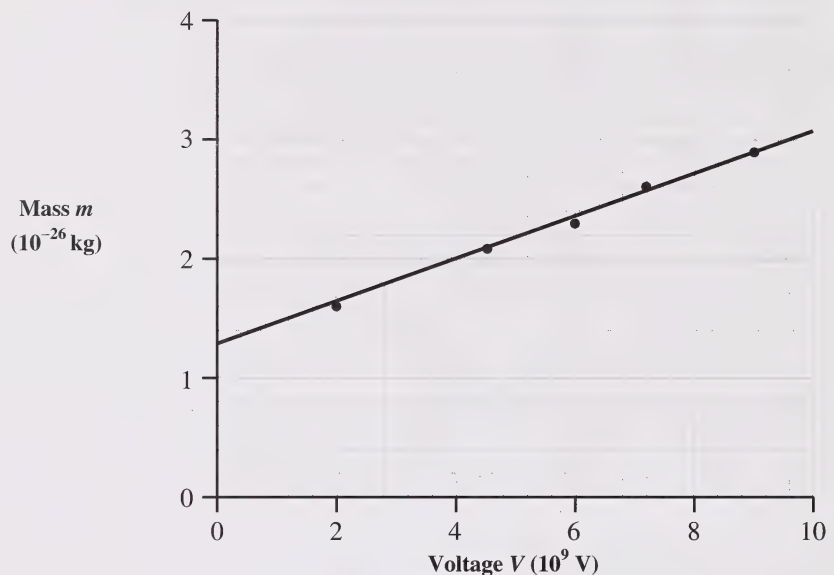
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Use the following information to answer question 3.

A beam of identical particles is accelerated using a series of large voltages. The particle mass is measured in a circular orbit at each voltage. The results of the experiments are summarized in the graph of relativistic mass m as a function of voltage V . The relation between these two variables is given by the equation:

$$m = \frac{q}{c^2} V + m_0$$



A student followed these seven steps to determine the best estimate for the charge on a single particle.

Step	Description	Calculation
1	formula	slope = rise/run
2	substitution	slope =
3	answer	slope =
4	formula	slope = q/c^2
5	rearrangement	$q = c^2(\text{slope})$
6	substitution	$q =$
7	answer	$q =$

(5 marks)

3. a. Neither of the calculations on page 26 are complete. Rewrite steps 2, 3, 6, and 7. Include the missing numbers and the missing units.

- b. In a clear step-by-step manner, show how the unit in step 7 is obtained from the combination of units in step 6.

- c. Find the rest mass m_0 of the particle.

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(7 marks)

4. You are required to find the range of frequencies of the visible colours that are present in a light source that is not monochromatic.

Design an experiment that can be used to find the range of frequencies of the visible colours. Your design must include:

- i. a list of the equipment needed,
- ii. an outline of the procedure of the experiment and of the values to be measured,
- iii. a derivation of the equations and calculations that are needed to find the frequencies of the longest and the shortest visible wavelengths in terms of measured quantities. (Start your derivations from the equations in the **Data Booklet**.)

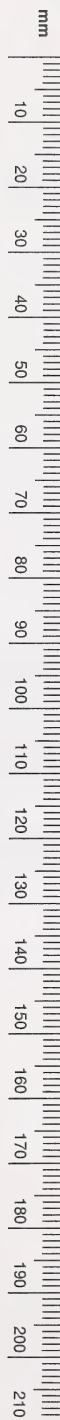
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***You have now completed the examination.
If you have time, you may wish to check your answers.***



No marks will be given for work done on this page.

Fold and tear along perforation.



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